



"Air Force research and development cannot be maintained at the highest level of competence without being closely associated with the general research effort of the nation's universities...

"A small fraction -- say two or three percent -- of the research and development budget of the Air Force should be consistently assigned for the purpose of making contracts with educational institutions for fundamental research in broad general fields on problems which, without being directed toward definite goals or applications, are of potential interest to the Air Force."

Another basic document is the Air University review of the Ridenour Report, sent on 18 November 1949 by General Kenney, then Commander of the Air University, to General Vandenberg:

"We are not establishing that partnership with science necessary to the exploitation of scientific frontiers, but rather we are alienating or ignoring vital segments of our national technical resources.

"Interaction between strategy and science is a primary requirement for an effective Air Force of the future... A positive system must be established whereby the interaction is not a voluntary function of personalities, but is an absolute and automatic result of normal staff functioning."

On 1 July 1951, Dr. Ridenour wrote to Lt Gen Partridge, Commander, ARDC, reviewing his report of two years previously and making certain recommendations, including the following:

"The Air Force should operate a program of contracts for basic research, mainly with universities of the country, rather like the program maintained by the Office of Naval Research...

"The areas in which research can be done are so vast that the Air Force can never hope to perform in its own establishment more than a tiny fraction of the work in which it will be interested. Thus the primary mission of ARDC in the field of research is to connect the Air Force with pertinent research being done elsewhere and to stimulate work that appears to be of direct interest to the Air Force."

On 23 February 1951, Colonel Frank J. Seiler, second chief of the Office of Air Research, described the "primary mission of the Office of Air Research is to sponsor, encourage, or take advantage of, in any way, all basic research to further Air Force ends. It is always necessary

to keep in mind Air Force needs. To talk in terms of a program, one must always ask the question, 'What problems need study or alleviation?'"

The comparison of the current mission of AFOSR - our role as we see it today and our objectives as we pursue them (Appendix 1) - with the original objectives for the AF contract research program reveals a striking and encouraging similarity. Also, it is important to note that the DoD written policy on the support of basic research has stayed constant from 1952 till today. This is set forth in the DoD Directive No. 3210.0, "Policy on Basic Research," of 19 June 1952, which made it possible for DoD to continue to sponsor basic research even after NSF had been set up. This policy states:

"To provide the essential foundation for the continuing evaluation of the weapons and techniques of war, the DoD must assure that basic research is adequately supported in all areas where the presence of knowledge is important to the military effort.... Research in the universities, non-profits, ... may be of a kind which does not have specific aims, but holds promise of some ultimate military applications."

From the above it may be observed that there has been a striking stability in the objectives for AFOSR. The original goals, the current AFOSR objectives and the long-standing DoD directives all agreed on the necessity of support of fundamental research in fields of broad general interest, which, without being directed toward definite goals or applications, are of potential interest to the Air Force. However, when one looks more closely at the environment for the support of research over this period, one sees rather violent oscillations with respect to what has been considered appropriate for AFOSR support.

Charles E. Wilson, Secretary of Defense in the period immediately following the establishment of OAR, defined basic research as "what you do when you don't know what you're doing," a sarcasm presumably to justify the inadequate funding of basic research. This certainly represented a violent swing toward a much more restrictive viewpoint than optimum. Nevertheless, through dedication and resourcefulness on the early leaders of AFOSR, the contract program was built. For example, Colonel Bill Davis divided basic research into two categories, calling the OSR contracts exploratory research and the in-house effort supporting research. Then, by implying that exploratory research wasn't really basic research at all, but an early stage of applied research (a category highly favored at that time in administrative circles), he got that year's OSR budget, which appeared as a B-52 line item, passed without question.

In 1958 the Air Force had a major review of the basic research program, and the results were set forth in the Stever Report. At that

time AFOSR had undergone some three years during which repeated requests had been made by higher headquarters to justify each and every AFOSR contract on the basis of its immediate application to Air Force needs. Out of this environment came an over reaction causing a swing to the opposite extreme. "Exploratory research," said General Gregory, then Commander of AFOSR, and the Stever Committee, "is basic research which is completely nondirected, has no specific end item in view, and is oriented only toward increasing the sum total of human knowledge." The Stever Committee Report went on to say, "The Air Force has a mission to sponsor and support exploratory research. In this way the Air Force shares with the other services the payment of research of general interest to the military. This ensures the establishment of effective lines of communication with all of the scientific community of the country, much of which will eventually but inevitably contribute to the USAF's ability to perform its mission."

At that point in time the relevancy considerations were interpreted very broadly, and in practice an oscillation occurred to the other side of optimum, at least from the standpoint of the amount of effort devoted to demonstrating the appropriateness of what we supported.

Now, this year we are in the process of what could be a very violent swing toward a very restrictive viewpoint. More will be said on this in the OAR part of the program, so I won't go into it now except to say that unless we take the right actions the Air Force research program could be set back quite seriously. The possible setback is of such a nature that the strength of the future operational Air Force could be seriously affected.

I believe that these serious oscillations in the policy on research are due in large part to our attempting to hang our hats on extreme positions on the support of research, for it is clear that a policy that lies far either side of what is considered to be optimum is bound to be temporary, and it eventually will be followed by a swing in the other direction, very likely overshooting, as we have seen. To avoid these vacillating policies, it is necessary to be able to recognize the extremes.

The one extreme I will designate as a "completely science-oriented policy." It goes this way:

The DoD is a big user of the results of science, and of the students educated, and therefore clearly should support the continuous replenishment of the pool they draw from. Further, the argument runs, multi-agency support of science is important and certainly the DoD should be one (or better four - AFOSR, ONR, ARO and ARPA) of these agencies, particularly since DoD controls half of the national budget.

This "completely science-oriented" argument for research in the DoD is doomed for failure on most fronts, I believe. I have time to discuss only one -- the Congressional front. While in January 1965, the Bureau of the Budget planned that NSF's funds for support of research programs would increase by about 70%, when Congress got done with their budget, NSF received barely 10% increase. While this action does not mean that in the long haul Congress will not support a growing program of scientific research in this country, it certainly seems to indicate that a mission-oriented agency such as the Air Force cannot expect to justify its program largely on the need for a continuing growth in general research.

I will dub the other extreme policy for DoD research support as "completely mission-oriented." It goes as follows:

The Air Force research exists solely to accelerate the generation of fundamental knowledge where the Air Force finds or predicts new requirements arising. While it is recognized that university research cannot in general be directly related to specific operational needs, all DoD supported research (including that in universities) will have to show clearly their relationship and application to service needs.

There appears to be a growing number of proponents of this latter point of view. They say, "Let NSF support the research that is not clearly related to DoD needs." This extreme is also doomed to failure for several reasons. I'll only mention two: 1) If we make this claim and are honest in what we do, we end up with an applied research, exploratory development program, so we have in effect discontinued the Air Force fundamental research program, not put it on a viable basis. 2) If, on the other hand, we keep a large fraction of fundamental research, while at the same time we claim that all of our work is clearly mission-oriented, we are also doomed to failure because the non-research oriented officials in Congress and other places show growing interest and capability in understanding what we are really doing. Further, even if we got away with hiding our fundamental research this way, our budget would not be what it should be because we would be hiding the greatest strength of our program from those who will support the budget when they understand the true role and importance of our program.

So one of our challenges for the future is to damp out these disruptive oscillations in the interpretation of the policy for the DoD support of research.

Our second problem area, which incidentally is closely related to the first, is a budgetary one. Figure 1 shows the AFOSR contract and grant budget for the last 10 years. The straight line shows the 6.3% per year

AFOSR PROGRAM DOLLARS
FY 58 thru FY 66
 (With 6.3%/yr cost-of-living reference)
 SRGP/MAP 15 Nov 65

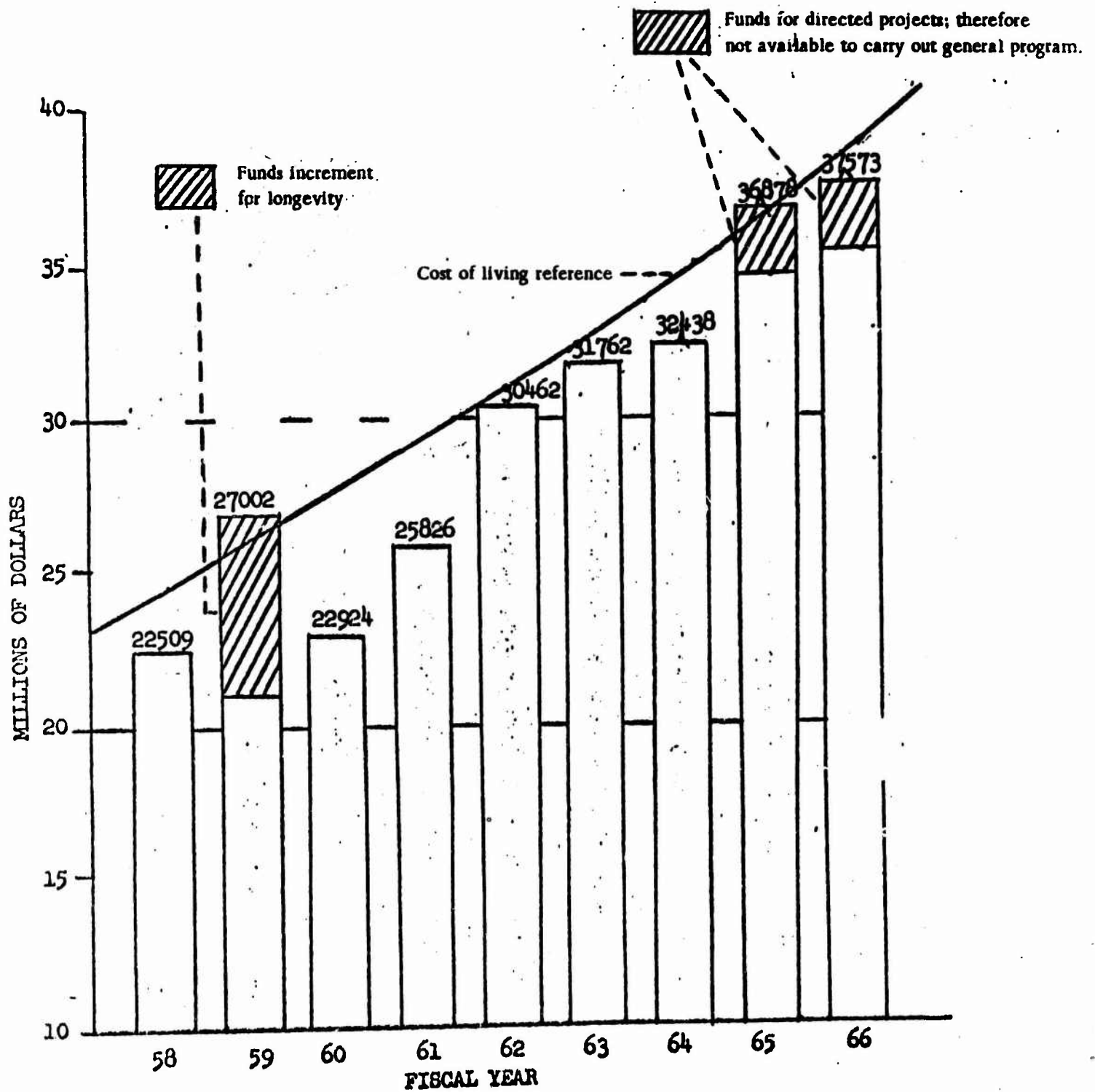


Figure 1

rise in cost of supporting a scientific manyear, so it is clear that we have lost ground in the total amount of research supported, particularly in the last four years. During the period when AFOSR's research budget had increased by a factor of 1.2, the NASA university support budget increased by almost a factor of 10, NSF's budget increased by a factor of 1.8, and the total funds for university research increased by a factor of 1.9.

What about the future? First, the budget picture -- it looks bleak - a flat or declining budget -- while at the same time we absorb increased costs through the removal of the grant overhead ceiling and also take on new directed efforts such as participation in the President's new program to develop new centers of excellence. What about the prospects of the Air Force keeping the much needed participation of a significant portion of the nation's top scientific talent? Our flat or declining budget (we are engaged primarily in orderly close-out of projects), coupled with growing budgets of non-DoD research support agencies, coupled with the rapidly growing requirement for more direct application of what we support, makes this a man-sized challenge for us in AFOSR -- I might even describe it as a serious problem.

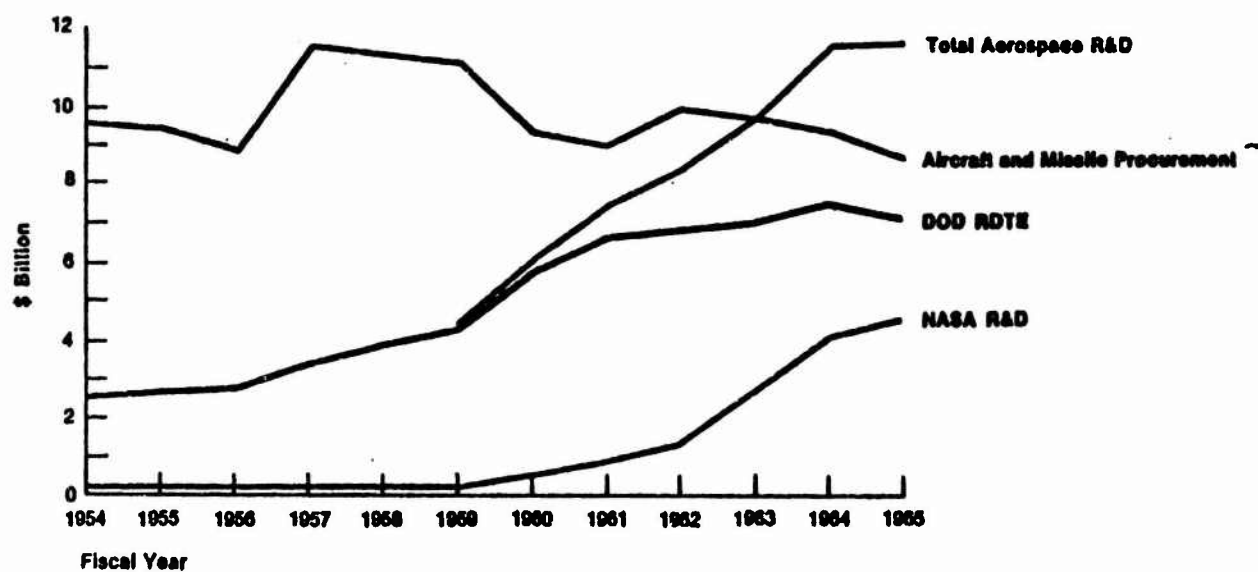
In describing the declining participation of the nation's scientific talent in the Air Force program as an undesirable situation and therefore a growing problem to the Air Force, I have tacitly assumed that the Air Force has a continuing need for a higher level of the basic research program. Let's examine the validity of this assumption.

In 1949, General Kenney in reviewing the Ridenour Report said, "The results of research and development are basically dependent on the pioneering thought processes of individuals; an environment to such thought is essential." What was true in 1949 is true many times over now. The Air Force is no longer primarily an operational agency. Rather, we help support Joint Operations under the command of the JCS and the DoD. Our role is to train persons for the Joint Operations and, what is much more important, to innovate through R&D to improve the future operational capability of the DoD. It is not to procure weapon system already possible within the state of the art -- that's DoD's function also -- but, rather, it is to carry out R&D up to feasibility phase and to perform trade-off studies in competition with the Army, Navy and ARPA.

With this type of mission, knowledge is power, and the sophisticated and timely scientific understanding that can only come from first-hand intimate involvement in science is essential. It is more essential now than it was in 1949, and it will certainly be more essential 10 years from now than it is today.

Perhaps the point can be made more clearly by making an analogy with the Aerospace Industries. Figure 2 is taken from the A.D. Little.

The Changing Pattern of the Aerospace Market



SOURCE: DOD, NASA

Figure 2

(Miller, T.G., Jr., "Strategies for Survival in the Aerospace Industry,"
A.D. Little, Inc., 1964, p 9, Fig 1)

Report, "Strategies for Survival in the Aerospace Industry," (Ref. 3). This study shows that of the gross business of the Aerospace Industries in 1965, 51% was in R&D as compared with 31% in 1959. It is interesting to note that people are beginning to speak about the R&D industry in the same sense that they describe the Automobile Industry, the Electronics Industry, etc. Now it is clear that the R&D Industry depends on fundamental research in a much more direct way than does any other industry. In the same sense, I believe that the Air Force is becoming more dependent on fundamental research, not less.

So the need for a viable Air Force research program is clear, I believe. How do we solve the problems of the declining budget and of damping the rather violent swing towards restrictive definition of relevance? I believe there is only one way to do this - that is to make sure: 1) that the objectives for the AFOSR program are proper; 2) that we achieve these objectives; and 3) that we properly communicate both these objectives and our accomplishments.

As the primary Air Force organization for dealing with the extramural research community, our objective is to do those things which help assure the maximum timely impact of the new scientific research activities throughout the world on the future operational Air Force. Appendix 1, "The Role of AFOSR," describes in some detail how the objective is pursued. It is seen that the two classical justifications for research which I have described above and designated as extremes actually are encompassed in this role but as part of a spectrum of contributions. In other words, the main strength and contribution of a fundamental research program for a mission-oriented organization such as the Air Force come from cultivating the ground in-between these two extreme positions on the role for research.

We have found it very helpful in thinking about AFOSR and its mission to describe it as a Research Institute (Figure 3). We have our AFOSR staff (the "Research Institute Managers") and various advisors and, of course, most important of all, the people who do the research. The AFOSR Research Institute can be visualized as a catalyst, interacting with both the scientific community and the Air Force. Both interfaces are of course very important. Scientific research is typically packaged in terms of the scientific disciplines. The DoD problems come packaged in other forms, and we have to work out interface problems of the type discussed by Dr. Alvin Weinberg in his Science article, "But is the Teacher Also a Citizen?" (Ref. 4). In this he describes an incongruity between the discipline-oriented goals of university and the mission-oriented goals of society.

AFOSR is well-suited for providing the required interface. Inasmuch as it consists of Directorates with names of the principal scientific disciplines and it has a well established reputation in the scientific community as a good research agency with which to work, it attracts

AFOSR as a "Research Institute"

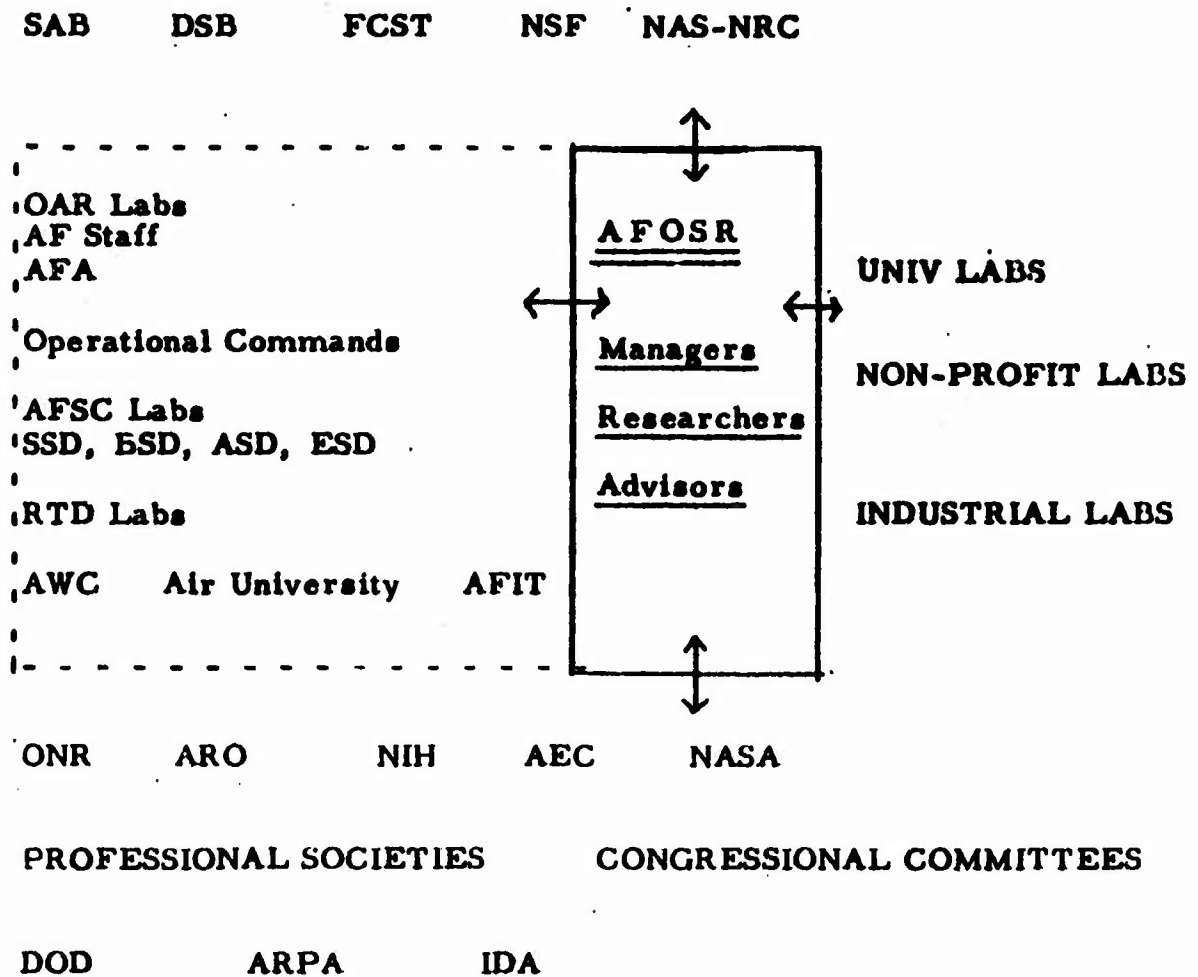


Figure 3

the interest of the world's top scientific talent. At the same time, staff members of the AFOSR Research Institute have the mission, experience and techniques required for identifying DoD problem areas and translating them into scientific research opportunities or, in reverse, in translating scientific knowledge and understanding into results for DoD users.

In providing this interface, the AFOSR Research Institute:

1. Accomplishes research. Our research is perhaps best described as phenomena-oriented research.* The most obvious goal is to understand or evolve a phenomenon or group of phenomena - in contrast to applied research or exploratory development, the primary motivation of which is to achieve an application. This phenomena-oriented research may be motivated by either helping a development group solve a problem -- we call this supporting-type research (perhaps problem research would be a better term) -- or by seeking fundamental or basic understanding required to pioneer or colonize new fields of science holding out high promise for scientific discovery from which innovations can arise which will bypass current technology barriers. But in addition to accomplishing research, we:

2. Provide communication between the scientific community and the using agencies. This is a two-way communication -- needs to the research program, and scientific information to the users. You know about many of the coupling activities in which we are engaged, and you will get more information on this today. Incidentally, part of what we purchase through contracts and grants is primarily designed to provide communication -- not only through the symposia we sponsor, but also the connecting-type research (see Appendix 1) which allows us to keep abreast of a variety of those scientific areas largely supported by other agencies in which rapid and significant developments of importance to the Air Force are taking place. The fact that our principal investigators are very willing and able to provide advice and information regarding the entire field in which they are working is a great asset in communication.

We believe that we understand our objectives and they are sound ones. There are three areas in which we are seeking to make major improvements:

* From time to time, persons and organizations engaged in phenomena-oriented research have the misfortune of having the term "pure academic research" improperly assigned to their work, where the notion of purity implies a conscious and even self-righteous disengagement from the pressures of necessity and use. This is clearly an improper label for any research organization performing this interface activity. For a very interesting discussion of this misunderstanding, see Ref. 5.

1. In our planning - There is a big challenge to improve the visibility and concurrently the overall credence and effectiveness in our methods of selecting research areas.

2. In our coupling - We seek to further improve both the effectiveness and efficiency of our coupling activities, inasmuch as the communication function is so central to our objectives.

3. In our public relations - We are seeking for improved ways to communicate both our objectives and our accomplishments. We are particularly anxious to find better ways of articulating what we know to be true -- that through AFOSR the Air Force received important benefits that cannot be obtained through research which is clearly allied to end items -- nor through the support of fundamental science by other agencies. Our major contribution is that we provide a mechanism by which highly creative science-oriented persons that would not otherwise be working for the Air Force are involved in the Air Force program in manners which both we and they agree to be mutually beneficial. We are thus at least partially tapping this important potential for the continued strengthening of the defense of the country.

In conclusion, I want to mention two commonly held opinions, both of which I believe to be unfounded. It is my opinion that the considerations above provide the background information required to refute them.

First, it is held by some that the fact that over the years the Air Force has supported a decreasingly smaller fraction of university research means that somehow the university research program is of declining importance to the Air Force. These same persons tend to favor further transfer of the responsibility from the DoD to NSF. I believe that this is a misconception largely connected with what I have called "the completely science-oriented" role for Air Force research and that it completely overlooks the vital interface role that our program plays. As the overall support of science increases and the scope of science increases with it, the Air Force's needs and opportunities to provide an interface with science are likewise increasing, not decreasing.

Second, some feel that the climate in Congress will not support a continuing viable program of university research by the DoD. They feel that there will be further restrictions on the amount and type of research that the DoD can support. This opinion is an understandable extrapolation of the recent report of the Military Appropriations Committee. However, in my opinion, Congress will continue to give adequate support to scientific research in this country notwithstanding the temporary setback experienced by both DoD and the NSF in the FY 66 budget, and, further, that Congress is more likely to be led to understand and support the scientific program presented by the science-dependent DoD than it is to support the relatively non-utilitarian

NSF program. Thus, the opportunity and challenge facing the DoD is to present its program and particularly its objectives, to Congress in such a manner as to capitalize on this very real latent interest in our research program.

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Appendix 1 - "The Role of AFOSR," AFOSR (SRG), Oct 65

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THE ROLE OF AFOSR

The Air Force is an organization that is clearly dependent on a science based technology for the accomplishment of its mission. Thus the challenge to AFOSR, the prime Air Force organization for dealing with the extramural research community, is to do those things which help assure the maximum timely impact of the new scientific research activities throughout the world on the future operational Air Force.

We have found it very helpful in thinking about AFOSR and its mission to describe it as a Research Institute. We have our AFOSR staff (the "Research Institute Managers") and various advisors and, of course, most important of all, the people who do the research. The AFOSR Research Institute can be visualized as a catalyst, interacting with both the scientific community and the Air Force. Both interfaces are, of course, very important.

The research we support can be conveniently divided into three categories -- pioneering-type, supporting-type, or connecting-type -- described as follows:

Pioneering-type research. AFOSR keys its support largely to pioneering or stimulating new sciences or new aspects of sciences which show promise for technological application to future Air Force operations. This research attempts to colonize new fields of science holding out high promise for scientific discovery from which innovations can arise which will bypass current technology barriers. Advance prediction of results or their possible applications can not be forecasted with any degree of certainty. The problem is to select from a large number of possible research projects those which hold the most promise of scientific progress toward general programmatic goals. Through the careful placing of part of its support in critical areas, AFOSR has stimulated or catalyzed the development of these scientific fields, thus bringing about a much more rapid rate of growth in important new areas than would otherwise have occurred.

Pioneering projects supported by AFOSR can throw open vast avenues of investigation and are repeated reminders that while basic research can be programmed, discoveries cannot. It is clearly apparent that high quality accomplishments do result when highly qualified

investigators are free to pursue their research without undue concern for the utilitarian value of their new knowledge. This is the traditional strength of science. And consistently we see AFOSR research projects yielding rich returns directly along lines of Air Force interests, clearly as a result of AFOSR project scientists skillfully relating these interests to the research proposals that come in for evaluation.

Supporting-type research. Another broad category of the AFOSR research program involves what has come to be called supporting-type research. This is aimed at acquiring knowledge or understanding needed to extend capabilities beyond the limits of present technology.

The initiation of this type of research requires a high degree of awareness of Air Force research needs on the parts of both the AFOSR project scientists and the investigators. However, while the scope of the inquiry is fashioned with these interests in mind, the investigators retain a great deal of freedom as to methods of approach and otherwise bring the full force of fundamental research methods to these more applied problems.

Connecting-type research. The Air Force's wide range of interests requires us to keep abreast of a variety of those scientific areas largely supported by non-Air Force agencies in which rapid and significant developments of importance to the Air Force are taking place. AFOSR does this by selecting researchers not only for the quality of their work but also for their ability to provide advice and information regarding the entire field in which they are working. Thus, by spending relatively small amounts of resources in each of these areas, the Air Force is able to capitalize on the much larger expenditures of others.

The direct involvement with the scientific community through all three types of programs described above brings very important benefits to the Air Force in addition to affecting the rate and nature of increasing scientific knowledge. This comes through the knowledge and understanding which can be brought directly to technology through consulting, participating on ad hoc groups with people with systems responsibility, etc. Not only do the results produced by AFOSR-supported researchers become evident, but what is often much more important than that -- these persons can act as a very effective retrieval link, if you like, for a broad spectrum of science. This is

possible since they have a very intimate knowledge of the status of other work related to their own specialty - that is, they are members of the so-called "invisible colleges" of specialists. Now in any competitive situation, whether it be in industry or in military, the competitors are drawing from the same body of world science while simultaneously contributing to it. It may be in the long run that how well this part of the job is done determines who has the competitive edge.

There is still another important aspect of this interaction with the agency's technology that is extremely important; this has to do with the feedback of needs to the research program.

Who better can understand the problem in scientific terms than the researcher himself if he really wrestles with the technology problem. Also, there is a very important motivational factor. If he gets intimate knowledge of the needs, he is much more likely to be motivated to do something significant about meeting these needs.

It's clear then that the interactions between the researchers and the Air Force technological community is an essential part of the AFOSR activity. Who is responsible for bringing this about, and how is it done?

The management responsibility for this coupling lies with the individual AFOSR staff scientists. This part of their function is essentially an open ended one - that is, the opportunities are essentially limitless. It is one in which professional knowledge and ingenuity have a high premium.

Regardless of the background with which an AFOSR staff scientist comes to the job, he must keep current his contacts with counterparts in the Air Force applied research-exploratory development community. Here a lot of personal contacts are made by visits, correspondence, special reports, program reviews, participation in joint task groups, etc.

Some of the most meaningful coupling activities are those which directly involve the research scientists AFOSR has under contract. While these contacts are strictly voluntary on the part of the contractor or grantee, we find that scientists around the country are ready and willing to participate directly in Air Force activities in many ways.

Few examples include the following: trips to Air Force installations to perform consulting service; membership on ad hoc groups to study feasibility of various exploratory development programs; state-of-the-art reviews, either oral or written; special purpose symposia which are specifically designed to bring technologists and scientists together; special lecture tours; performance of feasibility studies on research phenomena to package them in a form more likely to be useful; and direct consultation with the aerospace industries. Many basic research scientists find very significant satisfaction and stimulation as they make these important contributions directly to the stature of the Defense establishment, in addition to the important contribution which they are making by virtue of adding to the fund of basic knowledge.

Thus, it is seen that the Air Force utilizes its extramural research program, administered through AFOSR, primarily to support highly creative science-oriented persons doing research, the utilization of which is not always immediately apparent. However, the Air Force is directly benefited by the Air Force science-oriented activity both because the talents of very capable scientists are brought to bear on fields holding particular promise to the Air Force and, what is perhaps even more important, the Air Force support of scientists provides channels by which they can contribute more directly to the defense of the country by consulting, etc., than would otherwise be the case. In addition, this Air Force support provides a number of other benefits, albeit less direct, associated with the general strengthening of science, through having multiple sources of support available, and with the increase in the supply of graduate students and our ability to recruit them for Air Force activities, etc.

In summary, the Air Force is committed to the support of fundamental science because we believe that this support brings the Air Force very direct benefits that cannot be obtained through research which is closely allied to the end items nor by the support of fundamental science by other agencies. We are committed to the unapologetic support of research which is admittedly strongly science-oriented. It pays very direct benefits to the Air Force. The major contribution of AFOSR is that we provide a mechanism by which highly creative science-oriented persons are involved in the Air Force program in ways which both they and we agree to be mutually beneficial. We are thus at least partially tapping this important potential for the continued strengthening of the defense of the country.

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13. ABSTRACT

The role of fundamental research in a mission-oriented agency is discussed with particular reference to the external contract and grant program of the Air Force Office of Scientific Research.

A brief historical account of the evolution of this program points up the tendency to describe the contribution of Air Force research in terms of extreme positions - either in completely mission-oriented terms in which all research supported shows clearly its relationship and application to service needs; or completely science-oriented terms which describe the Air Force research role as primarily a contribution to the large pool of scientific knowledge from which the Air Force and others draw. The point is made that the neglect of either position, and particularly of the role that lies between the extremes, is very unfortunate inasmuch as it results in missing important justification for the research program, and important guidance for the management of the program.

The AFOSR is described as a Research Institute - consisting of managers, researchers, and advisors - seeking to help insure the timely impact of science on the Air Force. In carrying out this role it accomplishes research and also it provides communication between the scientific community and the Air Force. The research accomplished is described as phenomena-oriented research which is motivated by either helping a development group obtain the required understanding of phenomena key to technological baselines or by seeking to pioneer or colonize new fields of science holding out high promise for scientific discovery out of which innovations may arise which will bypass current technology baselines. The communication provided is two-way: the user's needs to the research program, and scientific information to the user. Many techniques of coupling are employed, including specialized symposia and connecting-type research which allows the Air Force to keep abreast with those scientific areas that are largely supported by other agencies and rapid and important developments of potential importance to the Air Force are taking place.

14. KEY WORDS	LINK A		LINK B		LINK C	
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